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DAHLGREN, VA.



REPORT NO. 6-43

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EXAMINATION OF GERMAN 20 MM AIRCRAFT AMMUNITION

by  
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(SIGNATURE)

(RANK)

April 2, 1943.

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NAVAL PROVING GROUND

Dahlgren, Virginia

REPORT NO. 6-43

April 2, 1943.

EXAMINATION OF GERMAN 20 MM AIRCRAFT AMMUNITION

Naval Proving Ground Captured Enemy Equipment

Report No. 62

APPROVED:

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INSPECTOR OF ORDNANCE IN CHARGE

CLASSIFICATION (CANCELLED) (CHANGED TO)  
*Unclassified* BY AUTHORITY OF *NAVJAG 10/11/78 PAH*  
ON *7/1/84* (DATE) *B. Bragdon* (SIGNATURE) *SS11 10/31/73* (RANK)

Page 1

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## P R E F A C E

### AUTHORIZATION

Specific directives for this investigation were issued in Buord ltr NB100 (Relb) dated December 28, 1942.

### OBJECT

To make a complete physical, chemical and metallurgical study of two rounds of German 20mm aircraft ammunition.

### SUMMARY

A complete examination has been made of two rounds of German 20mm aircraft Oerlikon ammunition.

These two rounds used steel cartridge cases manufactured by deep drawing a spheroidized steel of approximately SAE 1020 grade. A study has been made of the hardness distribution and microstructure of these cartridge cases. It is shown that mouth-annealing has been used to obtain the distribution of physical properties necessary for proper obturation.

For climatic protection the steel has been coated with a clear lacquer; a pre-treatment similar to Parkerizing has been used to provide a satisfactory bond to the steel.

The projectiles of this ammunition possessed unusual features, one being thin walled and having high capacity and the other being of conventional HET design but having a rotating band made from a sintered iron powder compact.

A complete drawing has been made of the ammunition having the high capacity projectile.

## CONTENTS

	<u>Page</u>
I INTRODUCTION .....	1
II INVESTIGATION	
(A) PHYSICAL .....	1 - 2
(B) CHEMICAL .....	2
(C) METALLURGICAL .....	2 - 4

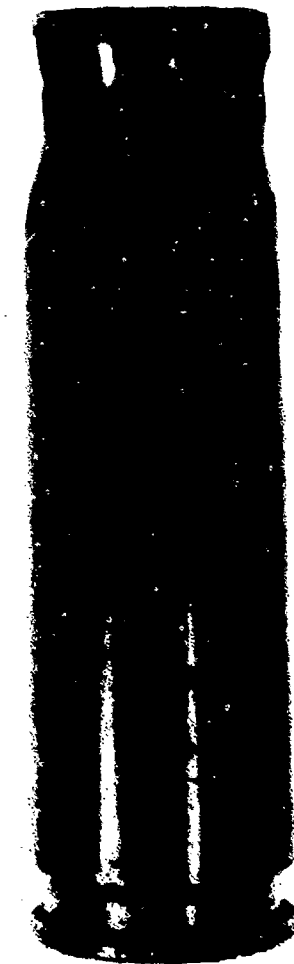
# LIST OF FIGURES

	<u>Opposite Page</u>
Fig. 1 - NPG Photo No. 626 (APL) Ammunition as received.....	1
Fig. 2A - NPG Photo No. 656 (APL) Acid etched cross-section of CEE 395.....	2
Fig. 2B - NPG Photo No. 657 (APL) Acid etched cross-section of CEE 394.....	2
Fig. 3 - Photomicrographs of cartridge case.....	3
Fig. 4 - Graph of hardness distribution of cartridge case.....	3
Fig. 5 - Microstructures of projectiles	4
<u>Drawing</u> NPG Dwg. 103 (APL) - Drawing of Round CEE 395.....	Inside back cover
<u>Tables</u> Table A - Chemical Analyses..	2

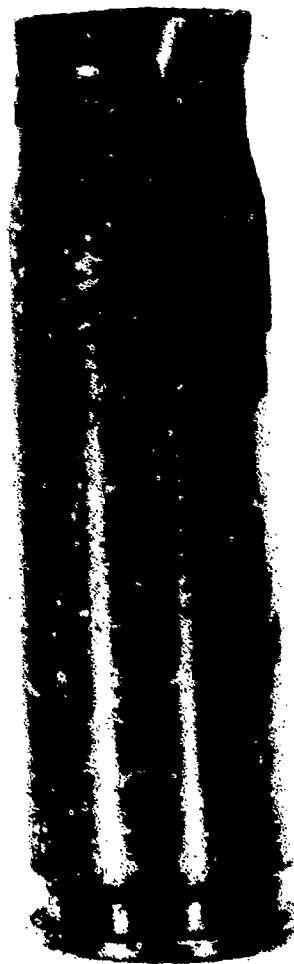
NPC PHOTO NO. 626 (APL) - Examination of Metals from Enemy Weapons.  
Report No. 62. German 20 mm. Aircraft Oerlikon Ammunition with  
steel cartridge cases. Figure 1  
March 22, 1943.

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CEE 395



CEE 394



## I

### INTRODUCTION

Two rounds of German 20mm aircraft ammunition were received on January 23, 1943, by the Armor and Projectile Laboratory of the Naval Proving Ground of Dahlgren, Virginia, for physical, chemical and metallurgical examination.

The ammunition was recovered following the crash of a German Focke-Wulf plane in Iceland on October 24, 1942.

## II

### INVESTIGATION

(A) PHYSICAL - Figure 1 shows this ammunition as received, unloaded and without fuzes. The following is a description of the characteristics, assembly and markings of this ammunition.

Round CEE395 - Aircraft Gerlikon ammunition using a steel cartridge case and a thin walled high capacity projectile. Figure 2A shows this projectile and cartridge case in cross section. The projectile had a total (unfuzed) weight of 40 grams and a capacity of .83 cu.in. The cartridge case weighed 63 grams and had a capacity of 1.35 cu.in.

The projectile was painted yellow with a black identification band around the mouth; the following code was stencilled in white at approximately midbody:

e d g 22141 as b 41 a 41

The portion of the projectile below the rotating band was left unpainted.

The cartridge case was coated with a clear lacquer and was identified by the following base markings:

1X 41 541 MEV/22

Round CEE394 - Aircraft Gerlikon ammunition using a steel cartridge case similar to that of round 395 but with a conventional HET projectile with a self-destruction feature. See cross section in Figure 2B.

This projectile had a total unfuzed weight of 85 grams and a capacity of .192 cu.in. of H.E. and .06 cu.in. of tracer compound.

TABLE A

CHEMICAL ANALYSIS OF GERMAN 20 MM AIRCRAFT AMMUNITION

<u>Round</u>	<u>C</u>	<u>P</u>	<u>S</u>	<u>Mn</u>	<u>Si</u>	<u>Cr</u>	<u>Ni</u>	<u>Mo</u>	<u>Cu</u>	<u>Zn</u>	<u>Al</u>	<u>MB</u>	<u>Pb</u>	<u>Fe</u>
<u>Round 395</u>														
Cartridge Case	.20	.021	.032	.35	.15	.07	.07	NT	100					
Projectile Body	.18	.016	.039	.75	.41	1.01	.07	.26	5.0	*	92	1.4	NT	.45
Fuze Adapter	-	-	-	.48	.44	.07	NT	NT					T	NT
Rotating Band														
Supporting Ring				.60	.60	.20	NT							
Primer Cup														
<u>Round 394</u>														
Cartridge Case	.19	.013	.019	.41	.10	.09	.07	NT						
Projectile Body	.51	.055	.067	.49	.43	.23	.07	NT						
Rotating Band	+	-	-	.20	.05	.10	.08	NT	*	*				
Primer Cup													T	NT

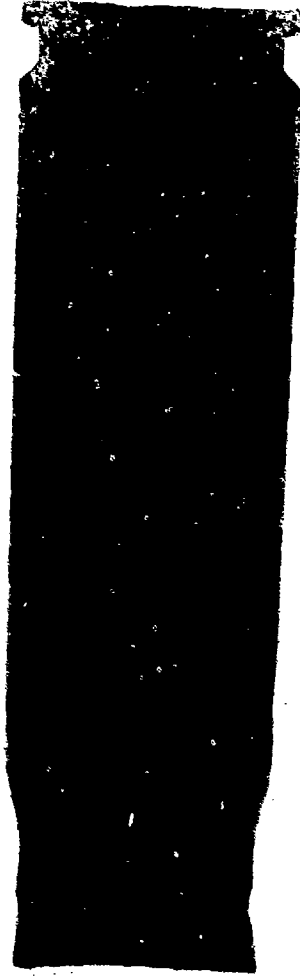
\* Predominant Spectrochemically.

+ Judged to be approximately .03.



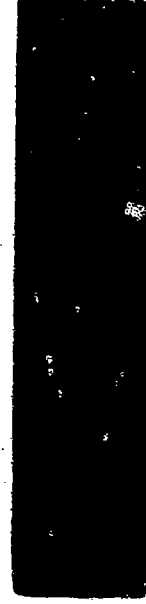
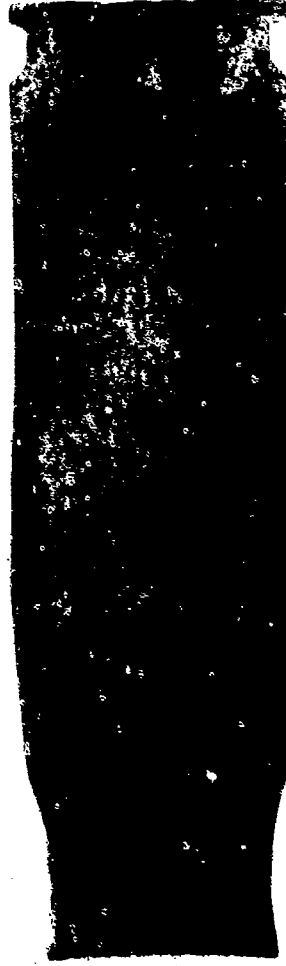
NPC PHOTO NO. 657 (APL) - Examination of Metals from Enemy weapons.  
Report No. 62. Macroetched cross section of German 20 mm. Oerlikon  
Aircraft Ammunition; steel cartridge case and HET projectile.  
March 22, 1943.

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NEG PHOTO NO. 656 (APL) - Examination of Metals from Enemy Weapons.  
Report No. 62. Macroetched cross section of German 20 mm. Oerlikon  
Aircraft Ammunition; steel cartridge case and high capacity projectile.  
March 22, 1943. Figure 2A

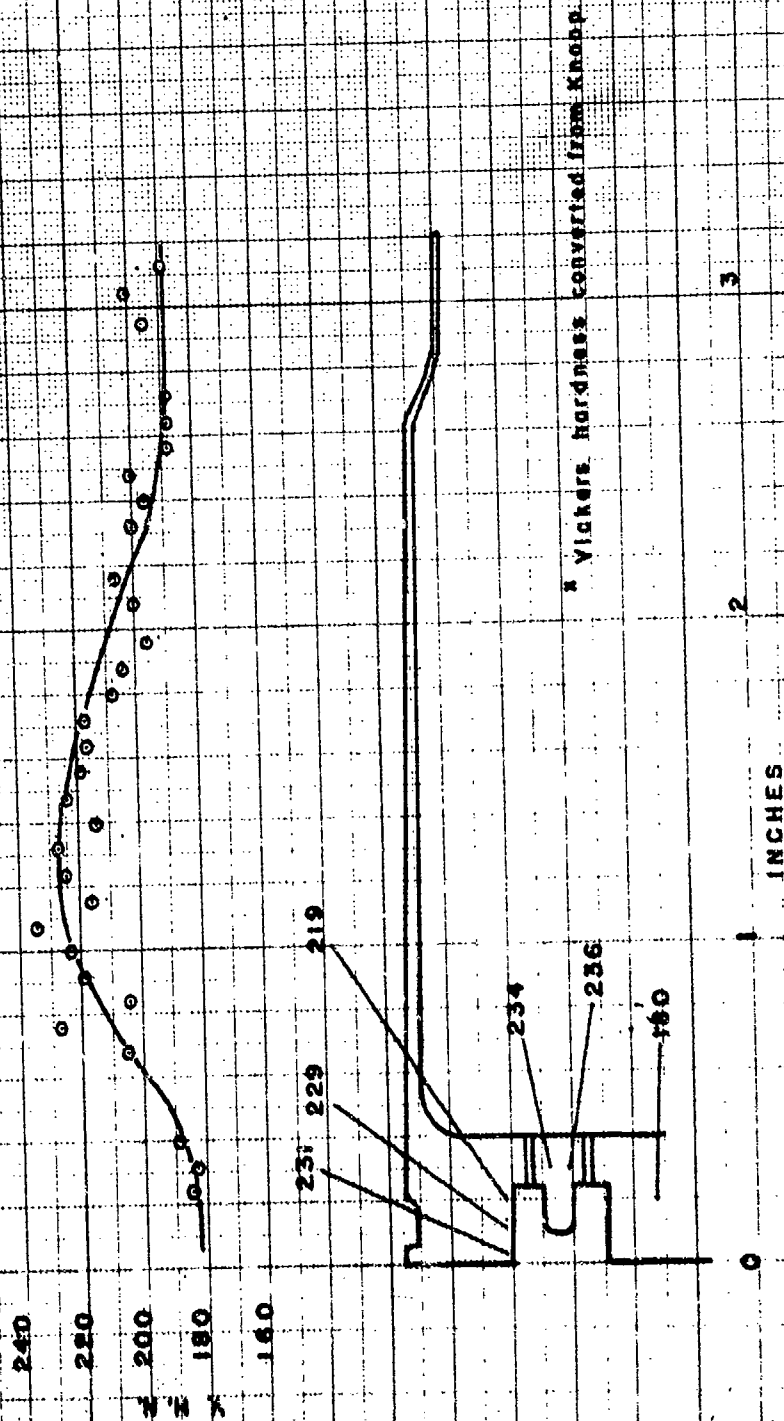
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CEE 395

FIGURE 4

VICKERS' HARDNESS DISTRIBUTION  
GERMAN 20MM STEEL CARTRIDGE CASE



\* Vickers Hardness converted from Knoop



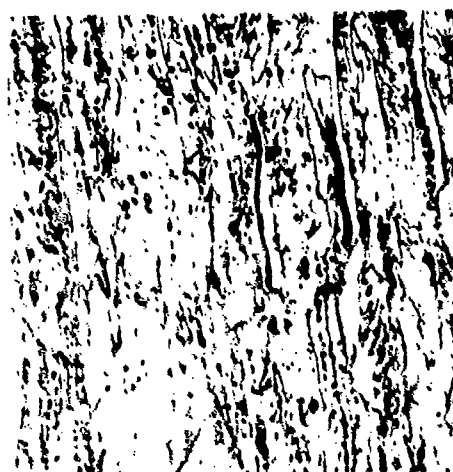
POSITION A



POSITION B



POSITION C



POSITION D



POSITION E



PHOTOMICROGRAPHS AT VARIOUS POSITIONS  
OF A 20 MM GERMAN STEEL CARTRIDGE CASE

FIGURE 3.

The hardness distribution (plotted in Fig. 4) shows that these cases have high physical properties, tensile and yield strength, along the center of the body and around the primer pocket resulting from cold work. These properties gradually fall off towards the mouth reaching a value almost as low as that of the original blanking as given by the head which suffered relatively slight cold working.

Such a distribution of hardness is necessary for a cartridge case must have high elastic properties along the body for proper recovery, and a soft mouth and neck taper region to permit proper obturation.

The hardness around the primer pocket is somewhat higher than the hardness along the center of the body. The deep etched structure of figures 2A and 2B show that this was obtained by a pocketing operation which cold-worked the metal; a fairly high hardness is desired at this point to prevent blowing out of the primer cup on firing. Such a method has evidently been successful for the primer cup is retained solely by a three-point star-crimp. (See Dwg. 103 (APL).)

The microstructure of the head (See Fig. 3, Position A) can be considered identical to that of the original disc blanked from the strip. It shows partially spheroidized, elongated pearlitic patches in a matrix of equiaxed ferrite grains. This is the structure of a hot rolled plate. The microstructures: positions B at the root and C and D along the body, show the same structure following progressively severe cold working. \* Position E at the mouth shows a recrystallized structure of small equiaxed ferrite grains resulting from annealing; to affect such a recrystallization of the cold worked grains the annealing must have been carried out at temperatures between 1000° F. and 1100° F.

These cases have a very good surface appearance, being practically devoid of die marks; a clear lacquer, soluble in alcohol and mineral acids and insoluble in water, coated the inside and outside surfaces. It appeared that this lacquer adhered well and would not chip off; however, its abrasion resistance appeared to be low - presumably it was sufficient to withstand the abrasive action of the propellant during transport.

The steel had been pre-treated for lacquering by a surface treatment similar to Parkerizing. Such conditioning is necessary for steel to provide a good bonding surface for organic coatings; it is not in itself a protection against climatic corrosion.

\* Magnification 500X for A, B, C & D  
750X for E

Etched Nitel

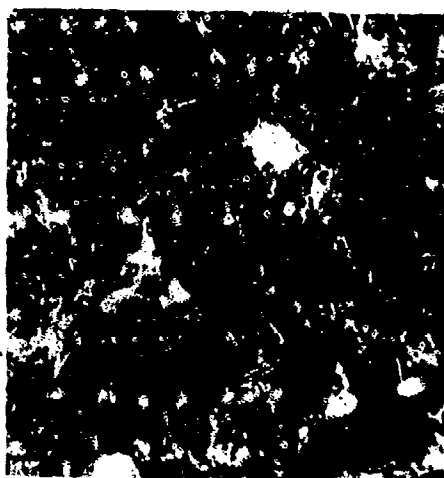


5A

Microstructure of iron rotating band; showing a partially recrystallized matrix of ferritic grains, with numerous and interconnective voids. Structure of a sintered iron powder compact.

MAGNIFICATION 200X

ETCHED NITAL

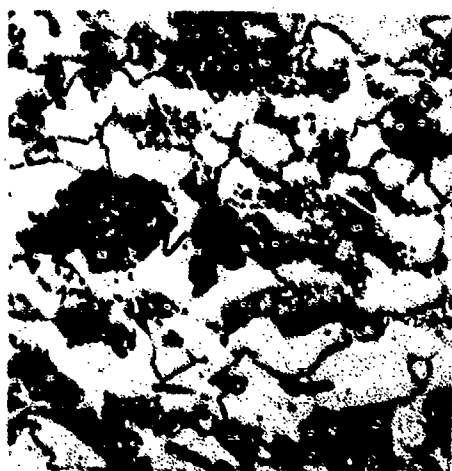


5B

Microstructure of high capacity projectile; showing a fine lamellar structure obtained on fast cooling.

MAGNIFICATION 1500X

ETCHED PICRAL



5C

Microstructure of H.E.T. projectile; showing normalized structure of a .50 carbon steel.

MAGNIFICATION 750X

ETCHED NITAL

FIGURE 5

High Capacity Projectile - The details of construction of this projectile are given in NPG Dwg. 103(APL); the novel body design permits an unusually high capacity of bursting charge.

Unlike the conventional 20mm H.E. projectiles which have thick walls, are machined from plain carbon steel bar stock and are not heat treated; this projectile is made by hot drawing a chromium-molybdenum steel (see Table A) and then oil quenching to produce a hardness of 38 - 40 Rc.

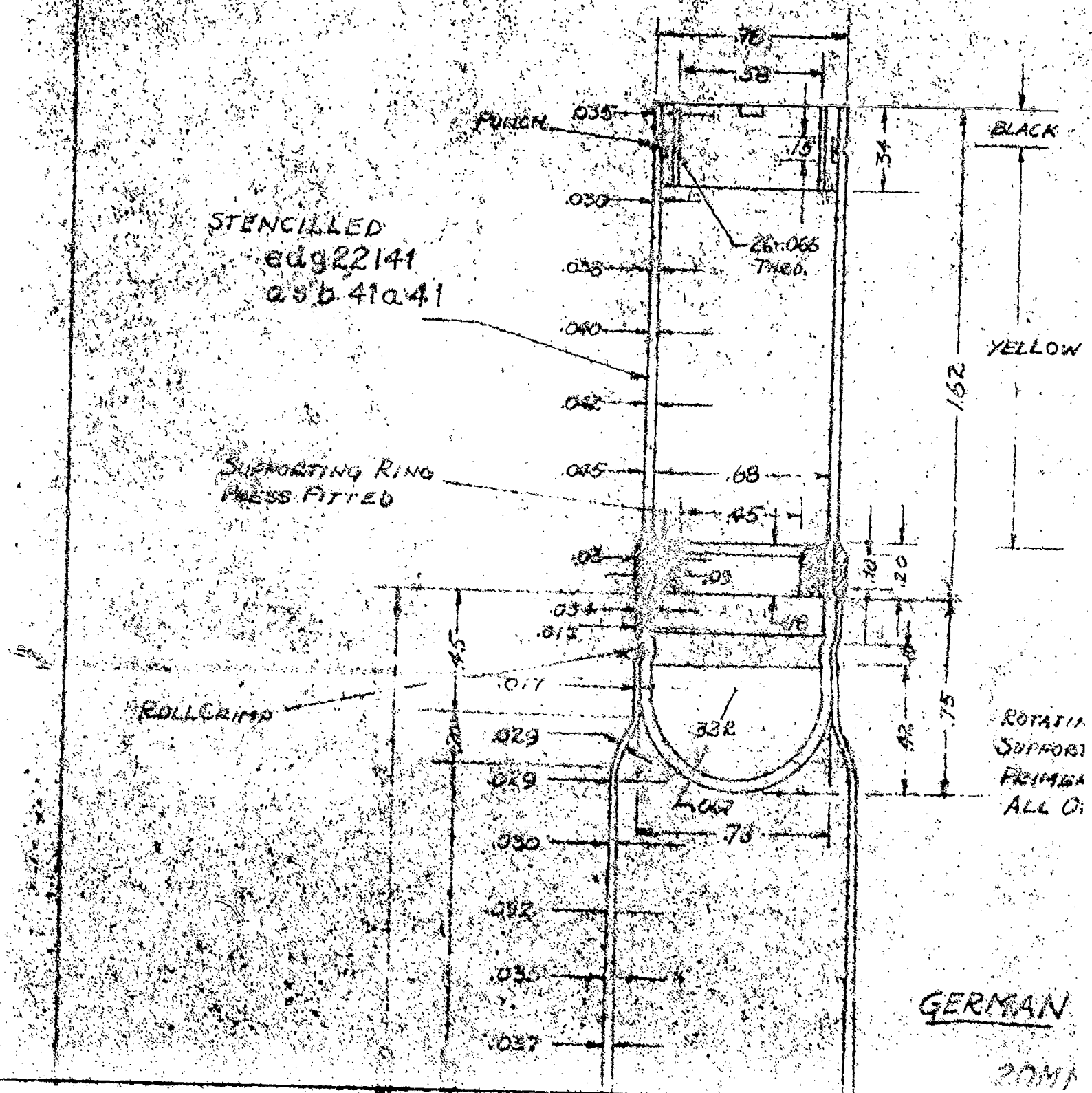
The microstructure (Fig. 5) shows a fine lamellar structure of carbides and ferrite plates typical for this steel composition when cooled fairly rapidly. It should be noted that there is no evidence of tempering. The hardness obtained represents the maximum which a steel of such low carbon content can be expected to show without a drastic quench to form martensite and then tempering. In applying the rotating band under a banding-press, the thin wall presents a special problem. This is solved by the use of a duraluminum supporting ring to strengthen the wall. The fuze is retained to the projectile by means of a fuze adapter which is punch-cripped in the projectile.

H.E.T. Projectile - The details of construction of this projectile are fairly conventional; a cross section is shown in Fig. 2B.

This projectile has been machined from a low chromium steel bar stock (see Table A); Fig. 5 shows the normalized structure which is probably that of the original bar stock; the hardness was 18 Rc.

The rotating band is unusual in that it is placed fairly well forward on the body (3/4 in. from the base) and that is made from sintered iron powder. It appears that neither the pressing nor the sintering of this powdered compact has been carried out to any great extent. Fig. 5 shows the discontinuous nature of the band which is the result of using fairly low pressures in the pressing operation. This band is apparently coined slightly oversize then sintered and finally pressed onto the projectile. The use of a supporting ring to prevent a collapse of the walls during this band pressing operation has been discussed previously.

This band was found to be very friable, breaking into many fragments while being removed from the projectile. Because of this brittleness, no reproducible hardness measurement could be made.





Technical drawing of a mechanical part, likely a propeller hub, showing dimensions and labels. The drawing is oriented vertically. Key features include:

- Top Section:** A rectangular section with a width dimension of  $1.0$  and a height dimension of  $.50$ . Below this is a smaller rectangular section with a width dimension of  $.15$  and a height dimension of  $.34$ .
- Central Section:** A large rectangular section with a width dimension of  $.68$  and a height dimension of  $.45$ . Below this is a smaller rectangular section with a width dimension of  $.09$  and a height dimension of  $.10$ .
- Bottom Section:** A semi-circular section with a radius dimension of  $.32R$ . Below this is a rectangular section with a width dimension of  $.78$  and a height dimension of  $.067$ .
- Labels:** The text "26-066" and "THRO." is written near the top section. The text "ING B", "RTING", "R Co", and "OTHER" is written vertically along the left side. The text "162" is written vertically along the right side.

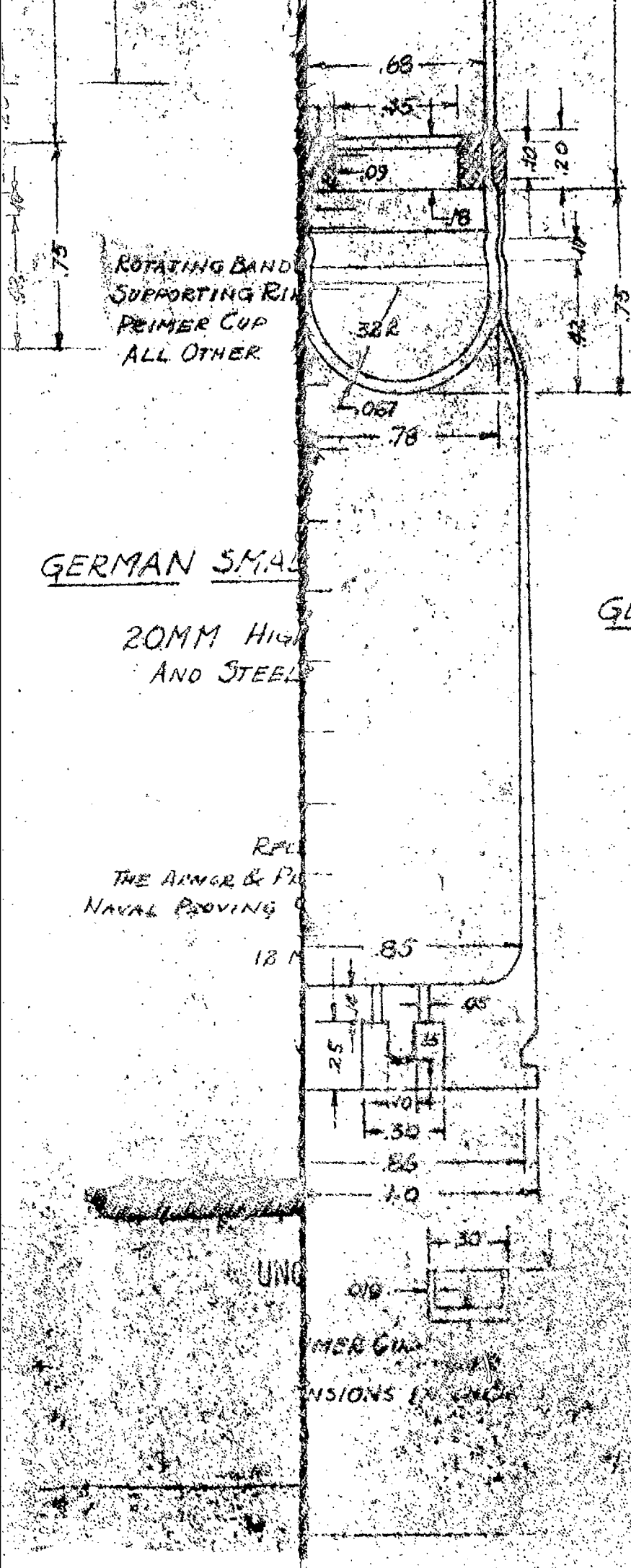
**YELLOW**

ROTATING BAND	COPPER
SUPPORTING RING	DURAL
PRIMER CUP	BRASS
ALL OTHER	LOW C STEEL

GERMAN SMALL ARMS AMMUNITION

20MM HIGH CAPACITY PROJECTILE





ROTATING BAND  
SUPPORTING RING  
PRIMER CUP  
ALL OTHER

ROTATING BAND COPPER  
SUPPORTING RING DURAL  
PRIMER CUP BRASS  
ALL OTHER LOW C STEEL

GERMAN SMALL

20MM HIGH  
AND STEEL

GERMAN SMALL ARMS AMMUNITION

20MM HIGH CAPACITY PROJECTILE  
AND STEEL CARTRIDGE CASE

REF.  
THE ARMOR & PRO  
NAVAL PROVING G

RECONSTRUCTED BY  
THE ARMOR & PROJECTILE LABORATORY  
NAVAL PROVING GROUND - DANFORTH, VIRGINIA

18 MARCH 1943

SCALE 2" = 1"

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MER GUN

ENSIONS IN INCHES

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103 AP